Ontario

GUIDELINES FOR INSPECTION AND ACCEPTANCE OF STAINLESS STEEL REINFORCEMENT ON THE CONTRACT SITE

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MINISTRY OF TRANSPORTATION
MATERIALS ENGINEERING AND RESEARCH OFFICE
CONCRETE SECTION

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Introduction

MTO has used stainless steel reinforcement since 1996; first on an experimental basis and once its effectiveness was demonstrated, in concrete structures on corridors with the highest traffic volumes. Current policy introduced in the fall of 2000 extends the use of stainless steel reinforcement to structural components with the most severe exposures in terms of likelihood of corrosion damage occurring and resulting in damage to the structure.

Designers specify stainless steel when corrosion resistance is of primary concern. By specifying stainless steel, the intent of the bridge designer is to achieve a long design and maintenance-free life and may be the preferred option for bridges that are inaccessible for future maintenance (i.e. high traffic areas).

The advantage of stainless steel is the extremely slow rate at which it corrodes in a concrete/chloride environment. Minimal corrosion damage is anticipated during a service life of 75 years. Although it is much more expensive to purchase than black or epoxy-coated reinforcing steel, it is more cost-effective over the long term because the corrosion-induced damage typically seen with black steel and coated steel will not occur.

Because of the premium cost of stainless steel reinforcement, and the very long term performance expected from the stainless steel reinforcement, it is very important to ensure at the time of arrival of the steel on site that it meets all specification requirements and that all the factors important for long-term performance are checked carefully. Severely damaged or contaminated stainless steel will compromise the long-term durability and will not achieve the goal of the designer or the bridge owner.

Specification Requirements

The requirements for stainless steel reinforcement are described in SP 905S04, October 2000 and 114S03 August 2000, which modify OPSS 905 and 1440 respectively. The Special Provisions identify the requirements for material properties (Type 316LN or Duplex 2205 Strength - Grade 420), marking of the bars (mill mark and size), mill certificates and information which must accompany the bars when they arrive on site, and requirements for manufacturer and fabricators to be listed on MTO Designated Sources for Materials lists.

All stainless steel reinforcement used in MTO work must be supplied by a mill listed on the Ministry's Designated Sources for Materials, List #9.65.76. In addition, fabrication (cutting, bending, shaping, making spirals) of the steel must be by a firm identified on this list. The list indicates clearly which companies may supply steel and which may carry out fabrication of stainless steel. If the steel has been supplied, or fabricated by a company that is not on the current version of this DSM list, the steel is not acceptable for use. This DSM list is updated as new companies are added or others are removed; make sure you have an up-to date copy of the list. (The latest version of the DSM can be obtained by contacting Ronen House at 1-800-856-2196 or www.ronenhouse.com).

Certificates and Tags

Stainless steel that arrives on site should be tagged, indicating the mill and fabricator, stainless steel type and grade, and bar mark number including stainless designation. The steel should be accompanied by a "mill certificate" verifying that the bars conform to ASTM A955M, and CAN/CSA G30.18 where applicable, including the stainless steel type and name; chemical composition; finish; tensile properties and bend test results. These requirements are spelled out in SP 114S03. The mill certificate should be checked to make sure it includes all the information required by the Special Provision.

Bar Markings and Appearance

The bars should be marked with a symbol that indicates which mill they are from (this is another way, in addition to the certificate, to verify that they are from a company on the DSM list). The marking should match the paper work (e.g. tag, mill certificate) and if it does not it should be questioned. Marks are made on the steel when it is rolled into bars, so these markings are permanent and are a part of the bar. Bars are marked approximately every 1 to 1.5 m, and the marks will appear as a raised area of steel with a recognizable "picture" such as a letter of the alphabet or a shape like an empty box. Each mill has a special mark that only that mill uses; they must supply the ministry with this information when they are approved for use. Attached in Figure 1 are diagrams that show the markings used by all the currently-approved mills.

If the marking on the bar does not match one of these markings, inferior or unacceptable steel may have been substituted; this is a problem and the steel should not go in the work unless it can be confirmed in writing that the steel is from an approved source. This confirmation should be from the supplier of the steel, not just the contractor or fabricator.

The surface "colour" of stainless steel does not always look exactly the same. The surface should be uniformly silver-grey in colour, but it may be quite bright or it can be dull in appearance, and still be of acceptable quality. However, if the steel does not look grey and looks discoloured or has irregularities on the surface, it may be that something has gone wrong in the manufacturing process and that the performance of the steel will be affected. Typically for this kind of problem, the discoloration extends over all or most of the surface of the bar. The attached (Figure 2) scale provides some examples of acceptable and unacceptable stainless steel; the top two bars are acceptable, the bottom two, on which you can see discoloration of the surface and a "brown" appearance are not acceptable. Steel delivered to the site that looks like the bottom two bars is not acceptable; it should not be included in the work. These pictures have been discussed with the stainless steel industry and they are well aware of the quality of material that MTO requires. They, and the contractors, have also been provided with these pictures.

Surface Contamination and Mechanical Defects

The Special Provision 905S04 states "Reinforcing stainless steel bars at the time the concrete is placed shall be free of mud, oil and other contaminants that adversely affecting bonding strength, and deposits of iron and non-stainless steel.
Special Provision 114S03 states "Fabrication of reinforcing stainless steel bars shall be such that the bar surfaces are not contaminated with deposits of iron and non-stainless steels, or damage due to straightening from coil.

This is a different kind of problem from the surface discolouration described above, and may be harder to spot. The defects are generally a result of careless or improper transportation, handling or fabrication procedures. Defects may be localized and occur only in one part of a bar or at intervals along the bar.

For example, if stainless steel bars are bent on the wrong kind of equipment or improperly handled, steel from the bending equipment or the environment may be pressed into the stainless steel surface. What you will see, by the time the bar gets to the site, looks like "rust" on the bar. Since stainless steel itself does not rust, the sight of rust tells you that there is contamination on the bar. If the amount of rust contamination is excessive, or occurs frequently along the length of the bar, the reinforcing bar should be rejected.

The reinforcing bar should be rejected if:

i) any area of contamination of the stainless steel by iron exceeds 100 mm in length

ii) two or more areas of iron contamination greater than 25 mm in length occur along the length of the reinforcing bar

iii) there are frequent small occurrences of rust contamination along the full length of the bar.

Contamination of stainless steel is not just a "cosmetic" problem; in the long term, those contaminants on the bar can cause localized damage (pitting) that can be very harmful. This problem has already been seen on a number of contracts and is likely to occur again; the long term effectiveness of the stainless steel, and its value to us, is reduced if this kind of damage is present.

If reinforcing bars have been rejected due to excessive iron contamination, it may be possible for the contractor to have the bar treated to remove the contamination. This can be accomplished by mechanical cleaning with a (stainless steel) wire brush, by use of a polishing machine or even by chemical treatment (pickling) if the contamination is excessive or other approved methods are not successful.

Another problem that may occur is when mechanical damage to bars occurs during bending or straightening operations. For example, stainless steel coming from some suppliers may be supplied in the form of large coils, which are then straightened out and cut into bars by the fabricator. Sometimes this straightening is not done very well, leaving the bar "twisted" or damaging the deformations (i.e. the longitudinal rib may twist around the bar, or and rather than running straight along it) or flattening them out, and often leaving very sharp tears and edges along the bar. This is not acceptable, since the pattern of deformations on the bar may be destroyed or badly distorted. Handling of such steel with sharp projections may cause injury.

The attached Figures 3 and 4, illustrating unacceptable reinforcement that has been observed on MTO contracts, are intended to provide guidance to field staff in inspection and acceptance of stainless steel reinforcement. Captions on each figure describe the deficiencies.

There may be other types of contamination or damage that have not yet appeared in MTO work. If you have any doubt as to whether stainless steel supplied to an MTO contract is acceptable, contact your Regional Quality Assurance Section or the Concrete Section of the Ministry for assistance. Please keep both groups advised of any quality problems you find; part of their role is to ensure that problems are brought to the attention of the suppliers so that they understand very clearly what is acceptable, and what will not be accepted, on MTO contracts.

VISUAL GUIDE FOR INSPECTION AND ACCEPTANCE OF STAINLESS STEEL REINFORCEMENT

List of Figures

Figure 1 **Marking for Approved Mills**

a Valbruna

b Atlas/Slater

c Acerinox

d Talley

e Empire

Figure 2 **Acceptable/Unacceptable Examples of Surface Condition**

a Acceptable Surface Condition

b Acceptable Surface Condition

c Unacceptable; stainless steel has been contaminated due to excessive iron in rinse water. Rinse water requires periodic changing. (Related to pickling process).

d Unacceptable, surface has dull appearance, stainless steel was not left in acid bath for required minimum length of time. (Related to pickling process).

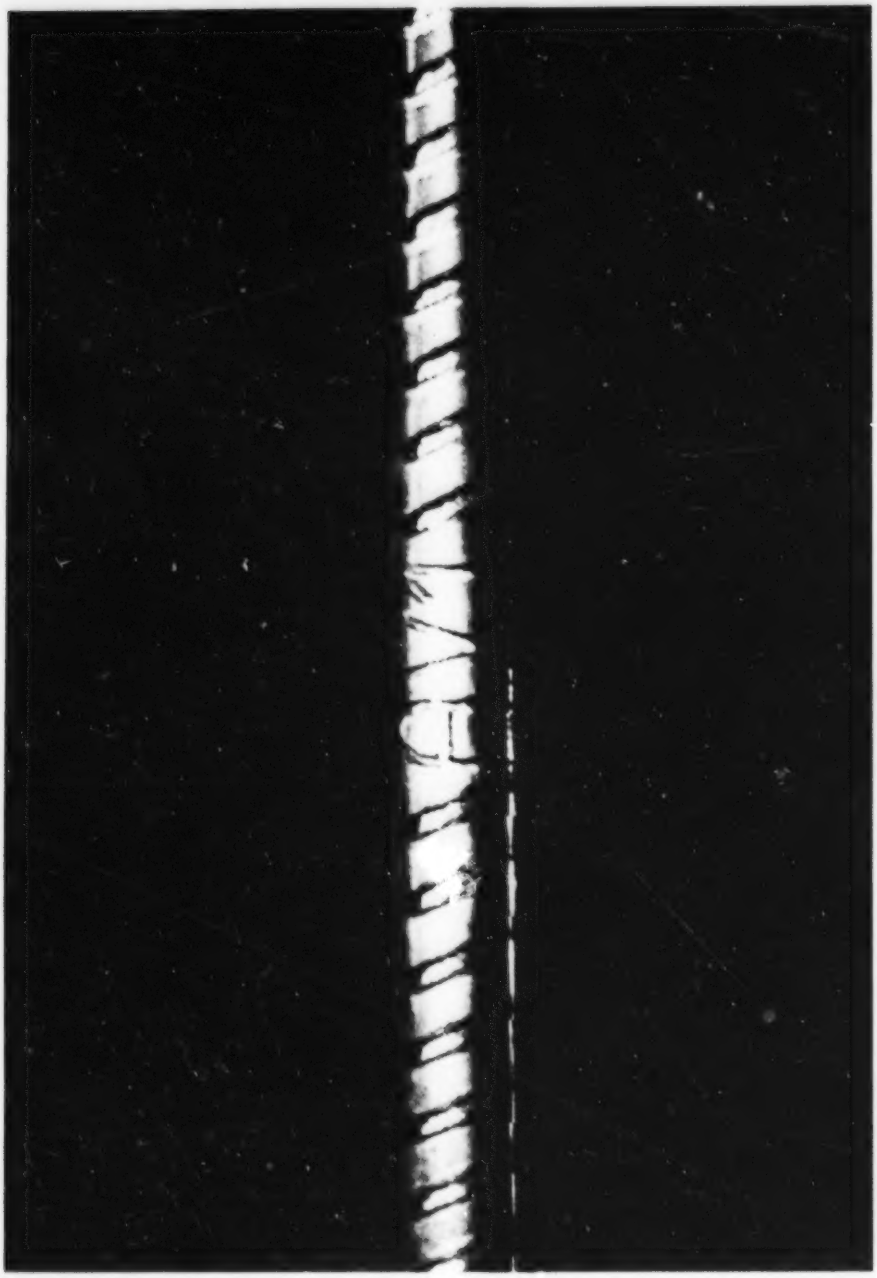
Figure 3 **Surface Contamination with Iron**

a Stainless steel with excessive contamination by iron particles.

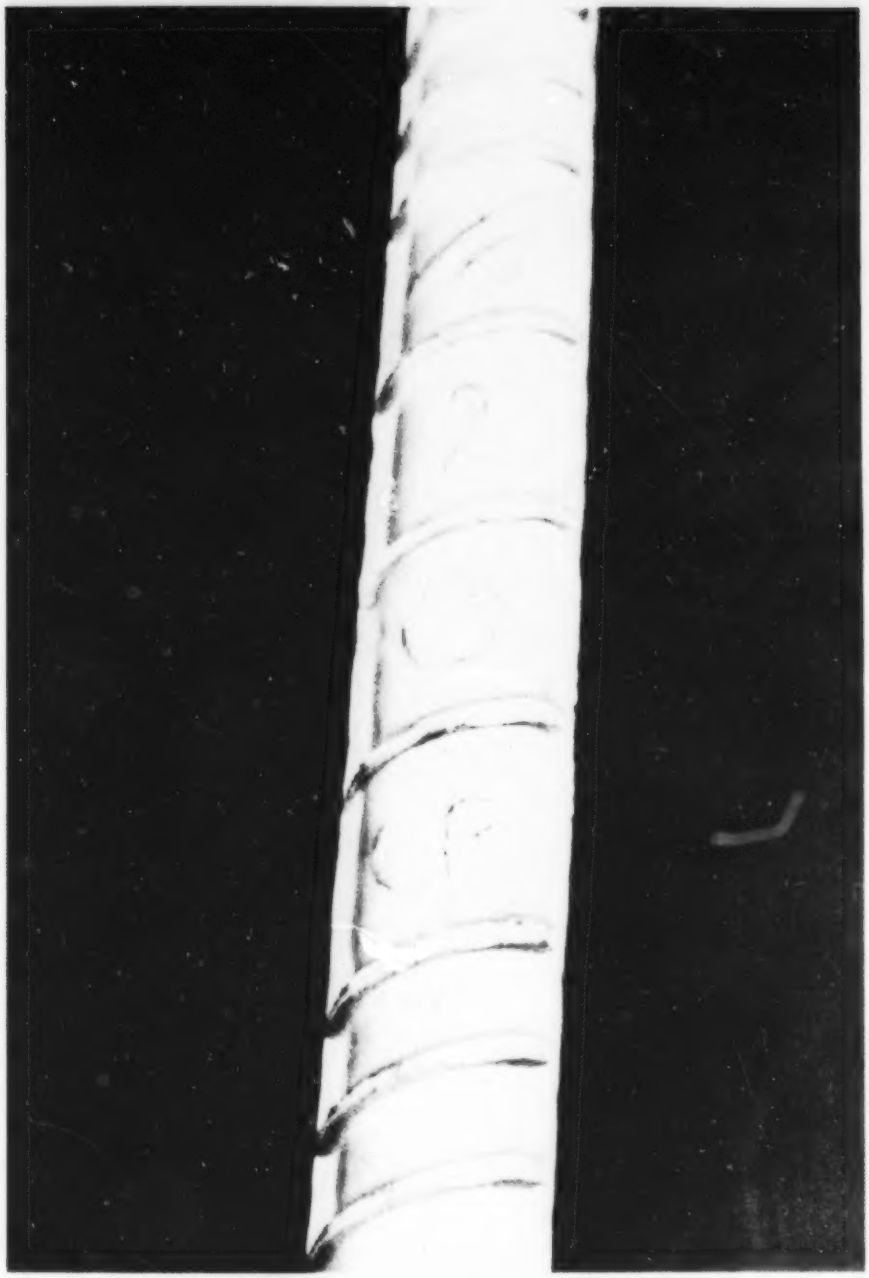
b Stainless steel bar with excessive iron contamination (contamination greater than 100 mm in length) due to spray of metal particles from adjacent black bar cutting operation.

Figure 4 **Mechanical Damage**

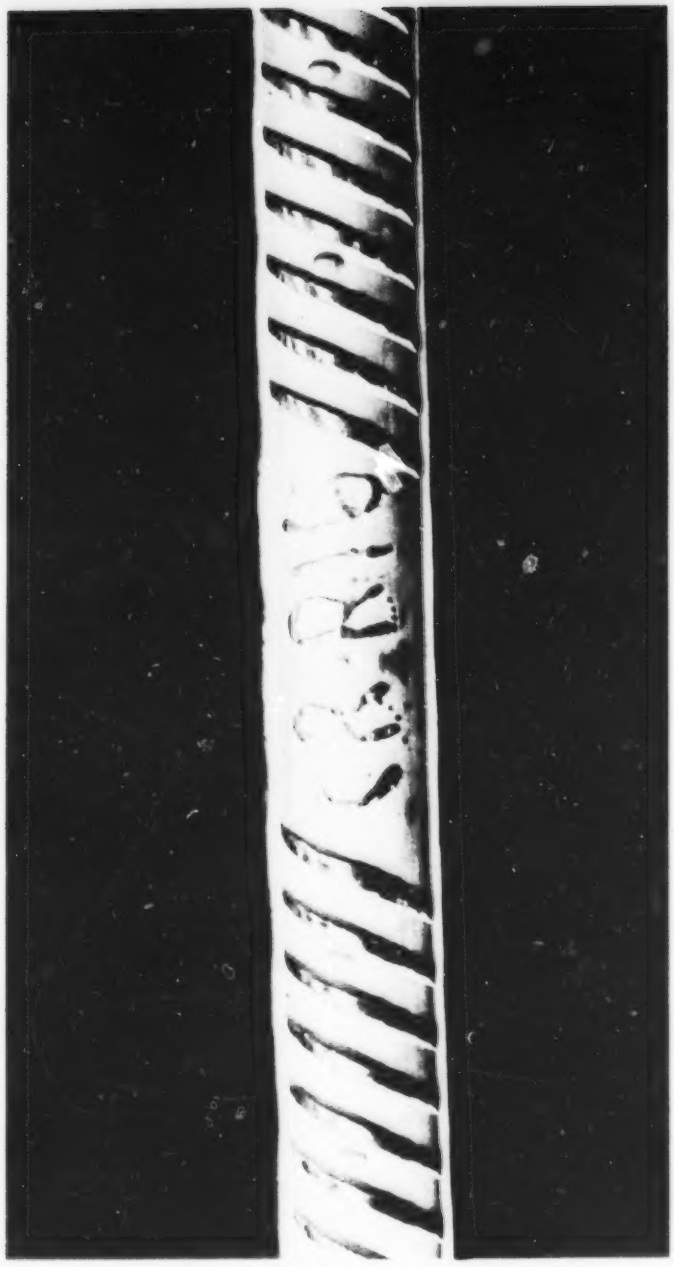
Stainless steel reinforcement that was straightened from a coil. The selection of the wrong equipment for straightening can damage the bar (flattening the deformations, gouging the surface) and reduce the corrosion resistance of the stainless steel.



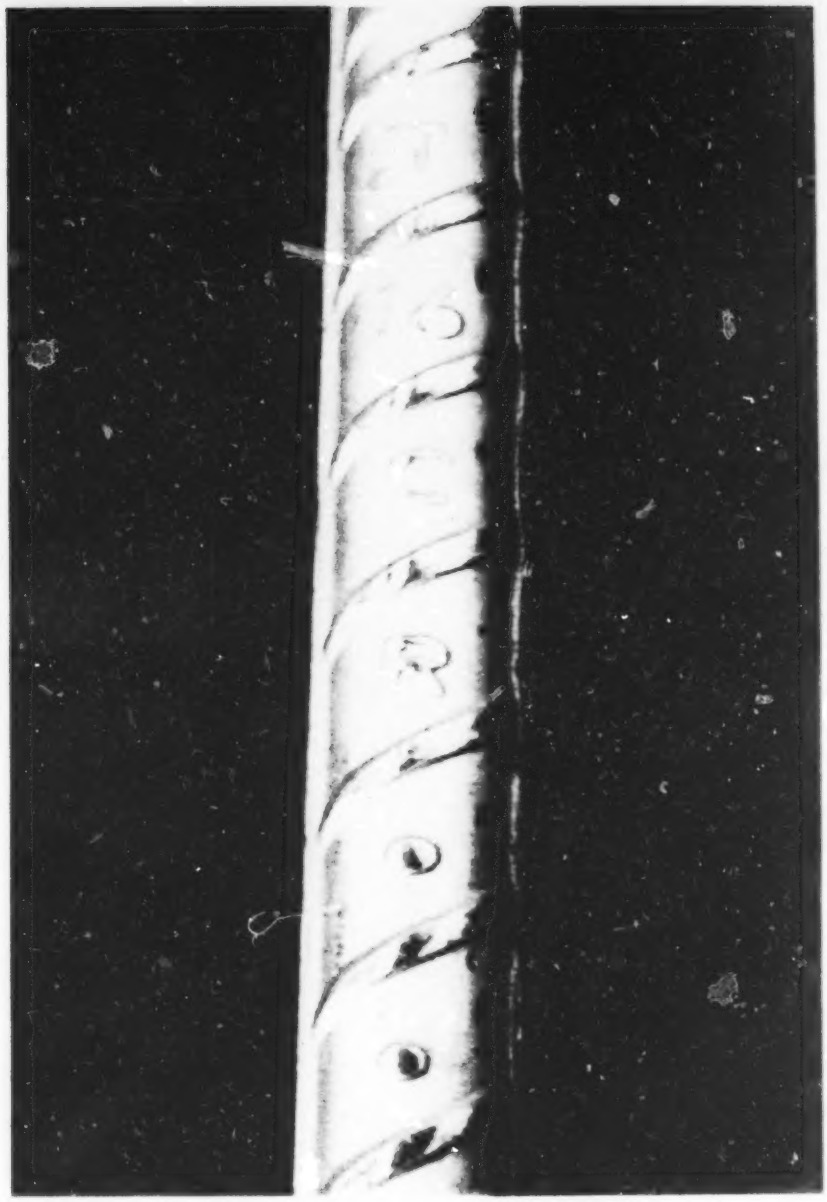
Mill Identification (Valbruna)
Figure 1a



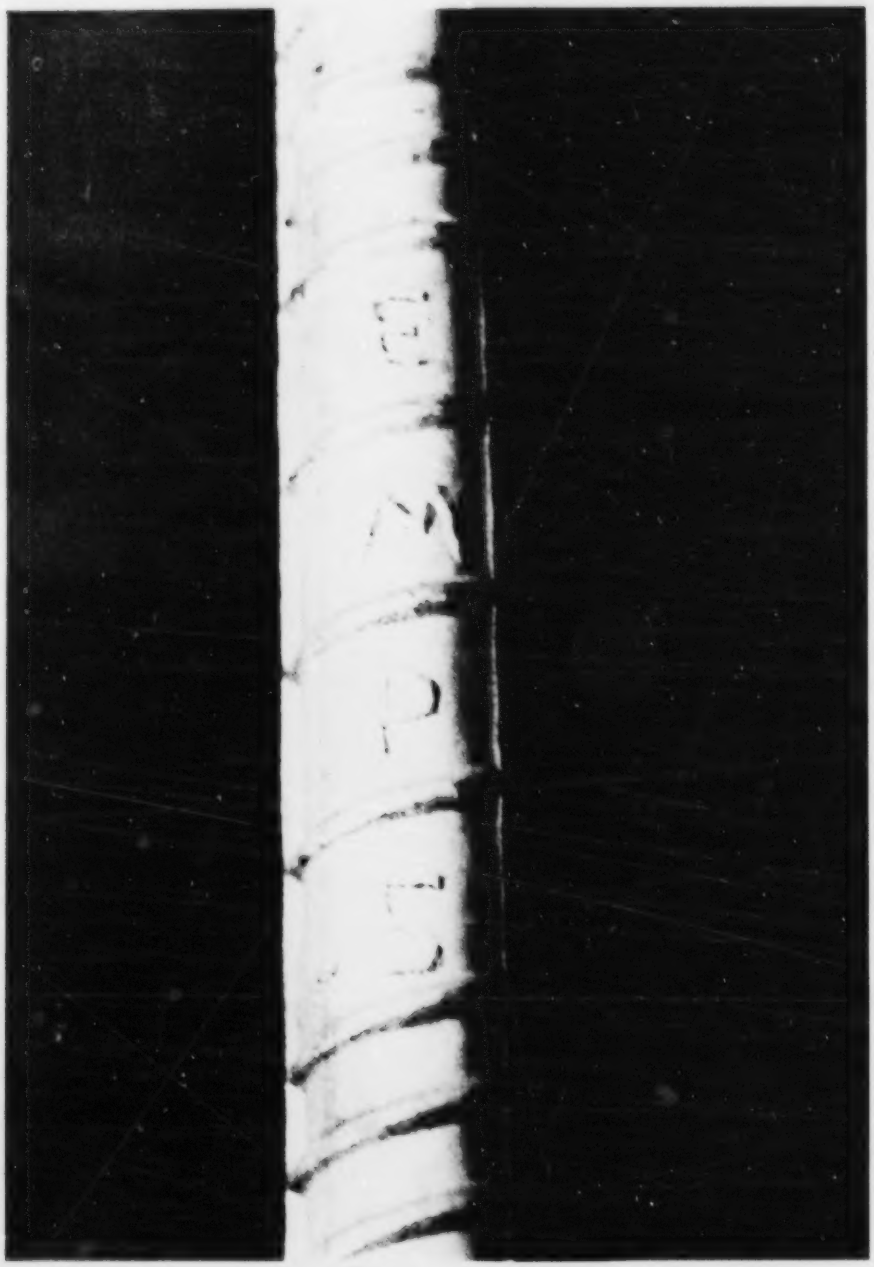
Mill Identification (Atlas / Slater)
Figure 1b



Mill Identification (Acerinox)
Figure 1c



Mill Identification (Talley Metals)
Figure 1d



Mill Identification (Empire Steel)
Figure 1e

Figure 2

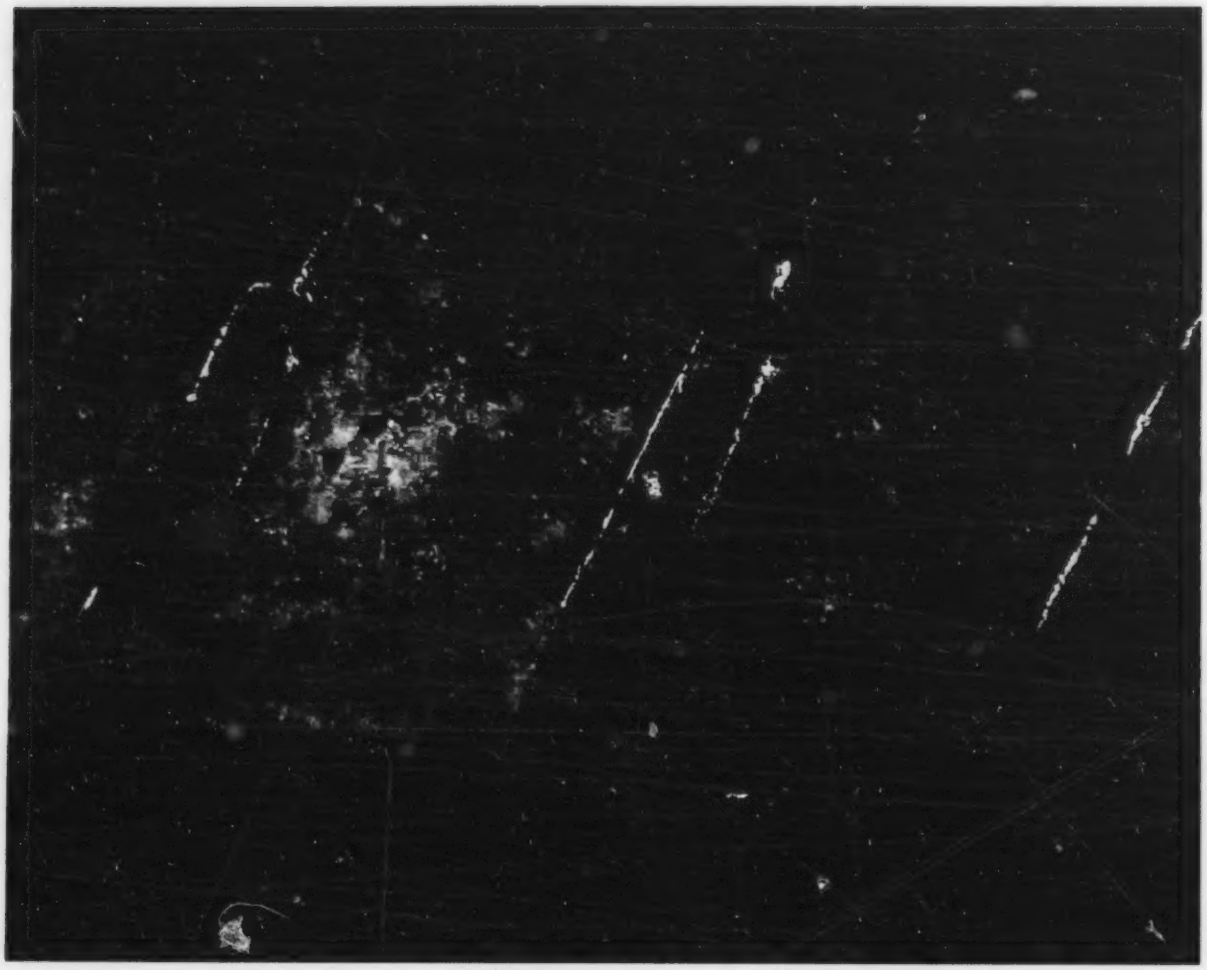


Figure 3a

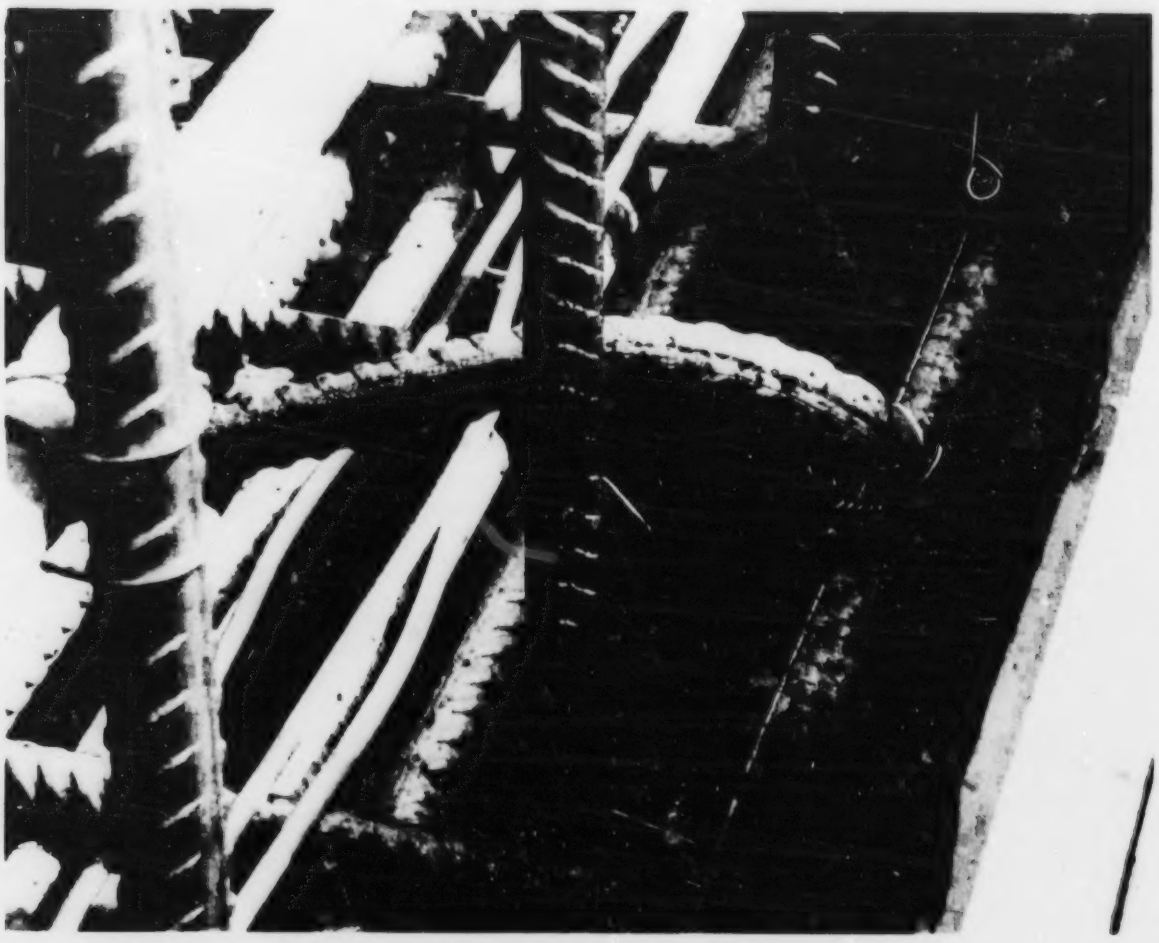


Figure 3b

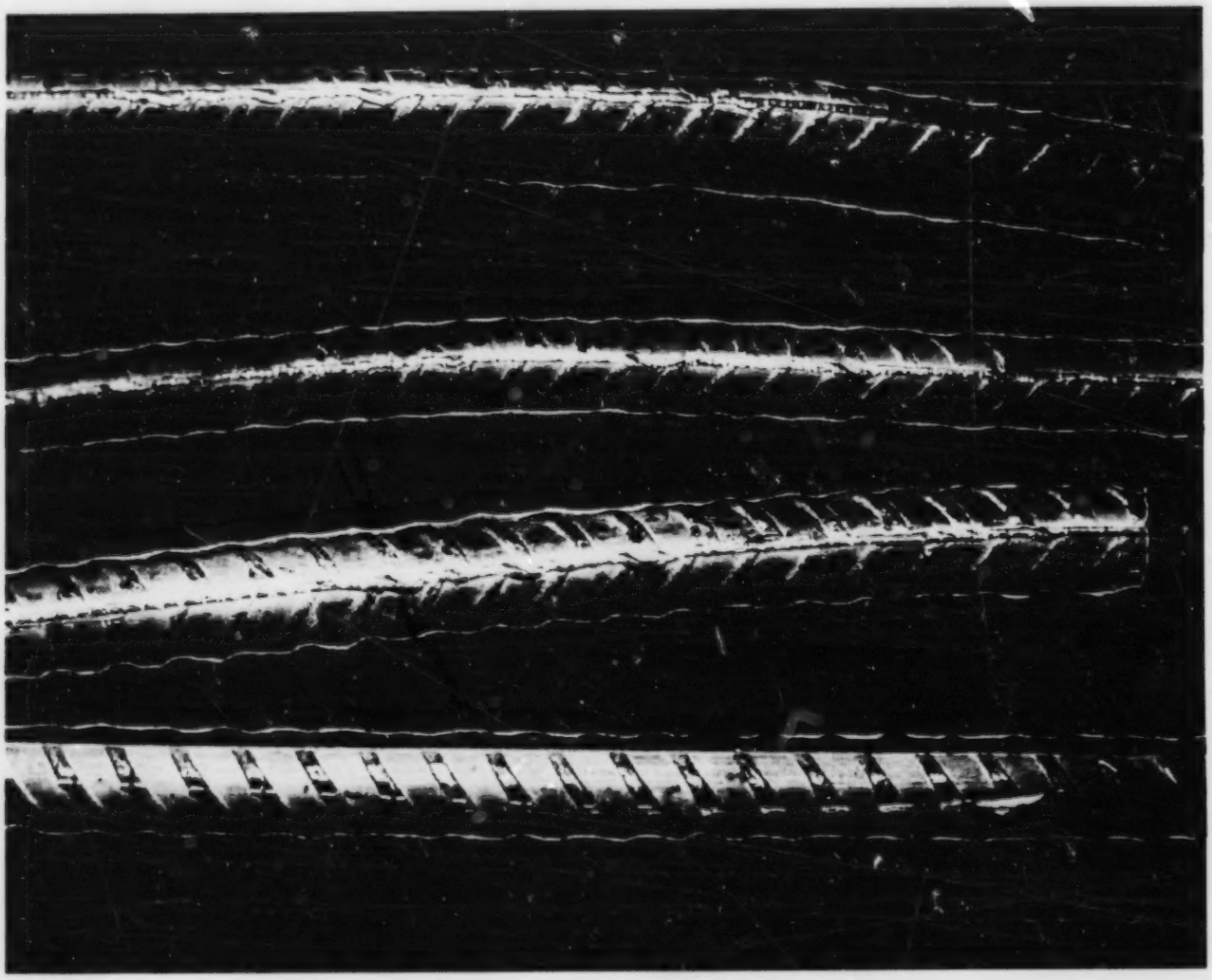


Figure 4 - Mechanical Damage